



MISSOURI  
STREAM  
TEAM

VOLUNTEER WATER QUALITY MONITORING  
LEVEL 2

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IF YOU DISCOVER A SERIOUS WATER POLLUTION EVENT OR FISH KILL, PLEASE REPORT IMMEDIATELY TO:

MISSOURI DEPARTMENT OF NATURAL RESOURCES

EMERGENCY RESPONSE UNIT 573-634-2436

[mdc.mo.gov/fishkills](http://mdc.mo.gov/fishkills)



# Volunteer Water Quality Monitoring Level 2

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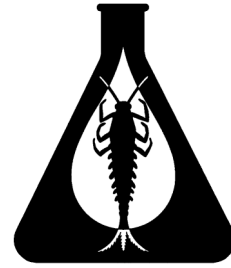
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# Introduction



The Level 2 workshop is a quality assurance/quality control (QA/QC) training. Quality assurance is the process used to measure and assure the quality of a product. Quality control is the process of ensuring products and services meet product expectations.

By attending this QA/QC workshop, the volunteer can demonstrate that their data meets the level of accuracy and consistency established by the VWQM Program. This data may then be used in a broader range of situations and can withstand most challenges to its validity.

## Quality Control Levels

The following are levels of quality control (QC) assigned to data in the Stream Team database:

- **QC Level 1:** Monitor has attended an Introductory and/or Level 1 workshop.
- **QC Level 2:** Monitor has attended a Level 2 workshop<sup>1</sup> and can correctly identify 75% of the invertebrates on an exam, not missing more than two EPT taxa<sup>2</sup>.
- **QC Level 3:** Monitor has been audited in the field by program staff and can correctly identify 90% of the invertebrates at their monitoring site, not missing any EPT taxa.

<sup>1</sup>To maintain a QC Level 2 or QC Level 3, monitors must attend a Level 2 or Level 2 Validation training every three years.

<sup>2</sup>EPT taxa includes the insect orders of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly).

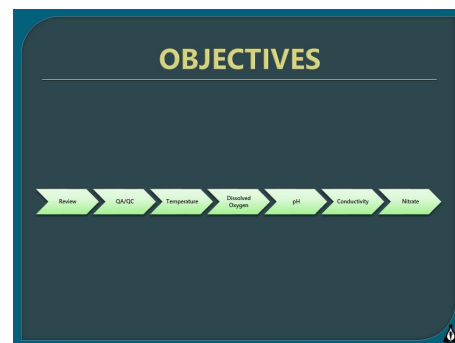


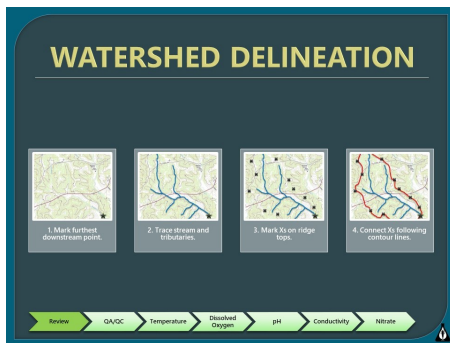
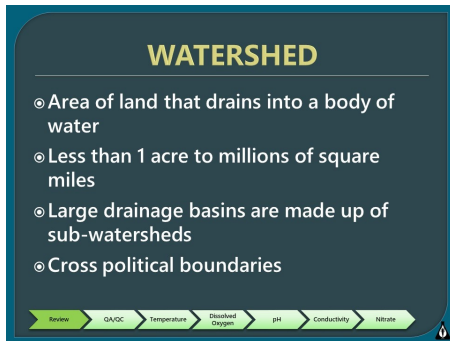
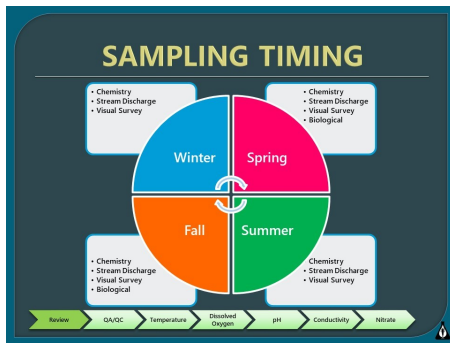
# Water Chemistry



Several factors can affect the accuracy of data. During the water chemistry QA/QC portion of the workshop, the reliability of equipment and viability of reagents will be checked. Proper sampling technique will also be assessed. In this section we will cover:

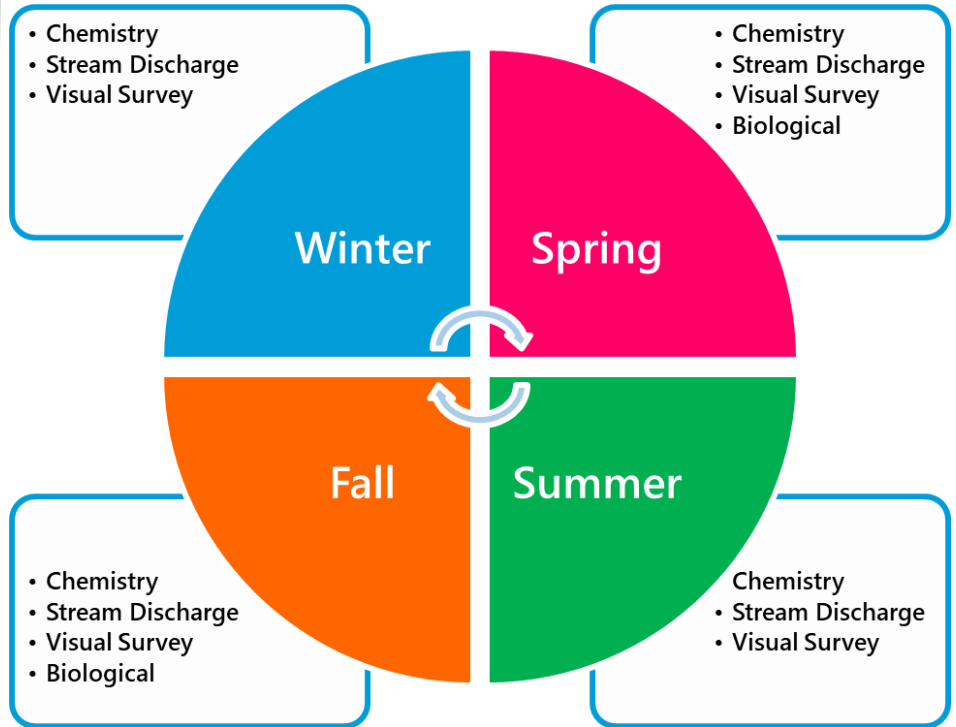
- QC Level 1 review
- QA/QC requirements and chemical disposal
- Temperature QC
- Dissolved oxygen QC
- pH QC
- Conductivity QC
- Nitrate QC





## Sampling Timing

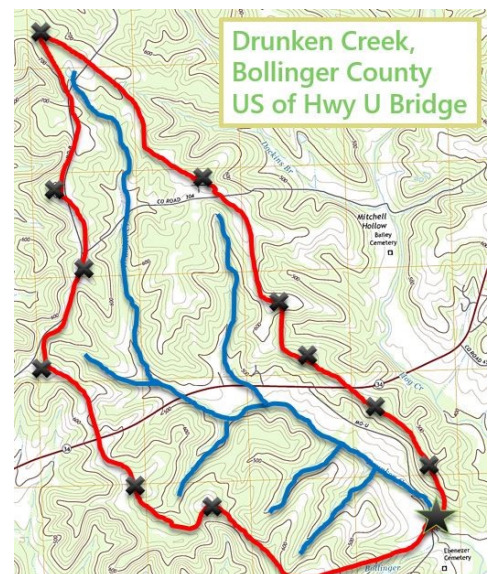
The frequency of monitoring is dependent on your goals or project. The VWQM program recommends monitoring at least four times a year, but no more than twice per year for biological monitoring at a given site. The most meaningful data is collected consistently over a long period of time.

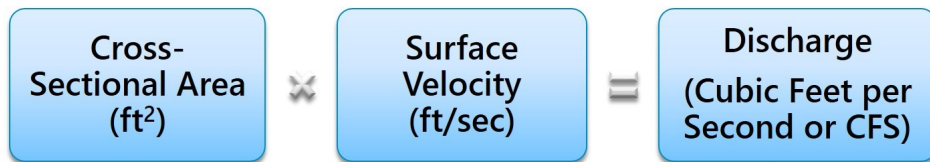


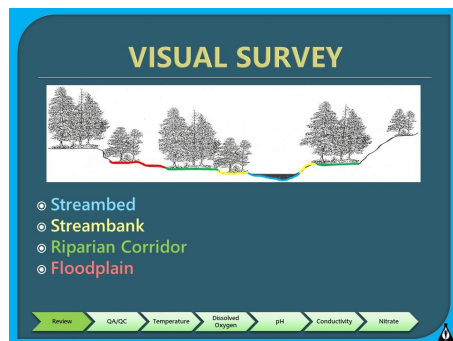
## Watersheds

A watershed is a topographically defined area that drains into a body of water. Watersheds can range in size from less than an acre to millions of square miles. To delineate the watershed for your monitoring site, follow these steps:

1. Mark your monitoring site on a topographic map, which is the furthest downstream point you will evaluate.
2. Trace the stream and all tributaries upstream from your site.
3. Mark an X on all ridge tops surrounding the stream(s).
4. Connect these Xs while following the contour lines.







## Visual Survey

Visual Survey is the physical assessment of your monitoring site. Since this is a collection of observations, it can be subjective. The Visual Survey datasheet should be completed by the same monitor at a given site to reduce variation based on opinion. It's most beneficial to collect this data at least twice a year, once with foliage absent and once with foliage present.

Observations in Visual Survey cover the following watershed components:

- **Streambed**—The area where a natural stream runs, or may run, depending on precipitation. This is the area between the streambanks in which substrate is deposited or removed by the energy of moving water. The streambed may be dry during times of the year, especially in the upper stream reaches.
- **Streambank**—The area of land that rises from the streambed and reaches a crest. Such crests are most noticeable when looking at the outside bend of a stream meander. If, and only if, there is no marked change or obvious crest, consider the bank to extend no further than 50 feet away from the streambed.
- **Riparian corridor**—The linear strip of land adjacent to the stream that is within the floodplain. There is variation in the definition of the riparian corridor, particularly related to stream width. VWQM protocol measures riparian corridor from the top of the streambank to 100 feet away from the stream.
- **Floodplain**—The flattened portion of the stream valley susceptible to large floods.

## Quality Assurance / Quality Control

Quality assurance (QA) is a set of activities that ensures processes are adequate in order for a system to meet its objectives. An example of this would be sampling protocols that monitors must follow. Quality Control (QC) is a set of activities designed to evaluate the developed products. Verifying the accuracy of a chemical test kit would be a QC measure.

To be considered accurate, the data produced from your analyses must meet the following acceptability limits:

Parameter	QC Limits
Temperature	$\pm 2^{\circ}\text{C}$ of meter
Dissolved Oxygen	$\pm 1\text{ mg/L}$ of meter
pH	$\pm 0.2\text{ pH units}$ of standard
Conductivity	$\pm 10\%$ of standard
Nitrate	$\pm 1.0\text{ mg/L}$ of standard

## Common Sources of Error

If a monitor does not meet the acceptability limits on the analyses, possible sources of errors must be systematically eliminated. The following is a list of possible problems:

1. **Reagents no longer viable**—Analysis should be repeated using viable reagents. Reagents should be stored in a low-moisture, temperature controlled environment.
2. **Equipment malfunction**—Troubleshoot following manufacturer's instructions and replace any damaged equipment.
3. **Analyst error**—An instructor should observe the analyst's technique.

### QA/QC

- Prevent defects
- SOPs

- ID and correct defects
- QC of equipment

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

### QA/QC

- Assures data validity
- Higher confidence in information generated
- Participation in QA/QC workshops demonstrates data meet specific criteria
  - Data can be used for a variety of purposes

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

### ACCEPTABLE QC LIMITS

To be considered accurate, the data produced from your analyses must meet the following QC limits:

Parameter	QC Limits
Temperature	$\pm 2^{\circ}\text{C}$ of meter
Dissolved Oxygen	$\pm 1\text{ mg/L}$ of meter
pH	$\pm 0.2\text{ pH units}$ of standard
Conductivity	$\pm 10\%$ of standard
Nitrate	$\pm 1.0\text{ mg/L}$ of standard

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

### SOURCES OF ERROR

- Reagents no longer viable
  - Expired
  - Improper storage
- Equipment malfunction
  - Electronic malfunction
  - Dirty or damaged glassware
- Analyst error

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate



### CHEMICAL WASTE

Chemical	Disposal
DO 1 packet	Dispose of packets unopened in trash receptacle
DO 3 powder pillow	
pH 7 buffer solution	
pH 10 buffer solution	
Sodium chloride	
Sodium thiosulfate	Flush down drain with ample cold water
Mixed acid	
DO 2 packet	
Nitrate reducing reagent	Return material to Stream Team program
Nitrate kit waste	

Review → DO/DC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

### CHEMICAL WASTE



Return hazardous waste to Stream Team workshop or DNR or MDC regional office

Missouri Stream Team  
800-781-1989  
[Streamteam@mdc.mo.gov](mailto:Streamteam@mdc.mo.gov)  
[Streamteam@dnr.mo.gov](mailto:Streamteam@dnr.mo.gov)

Review → DO/DC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

## Chemical Waste

The table below gives proper disposal instructions for commonly used VWQM chemicals:

Chemical	Disposal
DO 1 packet	Dispose of packets unopened in trash receptacle
DO 3 powder pillow	
pH 7 buffer solution	
pH 10 buffer solution	
Sodium chloride	
Sodium thiosulfate	Flush down drain with ample cold water
Mixed acid	
DO 2 packet	
Nitrate reducing reagent	Return material to Stream Team program
Nitrate kit waste	

Return hazardous waste to the Stream Team program for proper disposal as required by regulations. These may be dropped off at any Stream Team workshop, DNR or MDC regional office, or coordinate with program staff:



**Missouri Stream Team**  
2901 W Truman Boulevard  
Jefferson City, MO 65109  
  
800-781-1989  
  
[Streamteam@mdc.mo.gov](mailto:Streamteam@mdc.mo.gov)  
[Streamteam@dnr.mo.gov](mailto:Streamteam@dnr.mo.gov)



## Water Chemistry QC

Each monitor's chemistry test equipment and reagents will go through QC analysis during this training. The results will be recorded on the provided answer sheet and will be kept on file with program staff for three years until the next QC is required.

Program staff will provide standards and samples to measure. Each chemical parameter is analyzed as a group. Please do not work ahead.

**WATER CHEMISTRY QC**

Each chemical parameter will be analyzed as a group -- Please do not work ahead

NAME: \_\_\_\_\_ LOCATION: \_\_\_\_\_

VWQM LEVEL 2 WORKSHEET

PARAMETER	RESULT	RANGE	PARAMETER	RESULT	RANGE
Temperature (°C)		± 0.2	Dissolved Oxygen (%)		± 0.05
pH (25°C)		± 0.1	Ammonia Nitrogen (mg/L)		± 0.05
pH (25°C) Calibration		± 0.1	Ammonia Nitrogen (mg/L)		± 0.05
pH (25°C) Calibration		± 0.1	Phosphate (mg/L)		± 0.05

Review → QA/QC → **Temperature** → Dissolved Oxygen → pH → Conductivity → Nitrate

## Measuring Temperature

**TEMPERATURE QC**

1. Measure the temperature of the sample water on the table
2. Record result on the answer sheet

PARAMETER	RESULT	RANGE
Temperature (°C)		± 0.2

Review → QA/QC → **Temperature** → Dissolved Oxygen → pH → Conductivity → Nitrate

VWQM data sheets include air and water temperature, which should be measured in the shade. Measure air temperature first to avoid residual water on the thermometer affecting the temperature reading. When measuring water temperature, read the temperature while the thermometer is still submerged. Always allow several minutes for the thermometer to acclimate, especially in extreme temperatures.

## Temperature QC

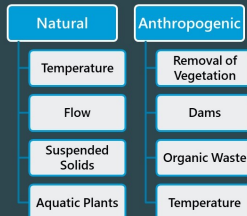
1. Using your thermometer(s), measure the temperature of the sample water on the table.
2. Record result on the answer sheet.

## DISSOLVED OXYGEN (DO)

- Includes concentration of DO (mg/L) and oxygen saturation (%)
- Oxygen saturation is temperature dependent
- Oxygen is more easily dissolved in colder water

Review QA/QC Temperature Dissolved Oxygen pH Conductivity Nitrate

## INFLUENCES ON DO



Review QA/QC Temperature Dissolved Oxygen pH Conductivity Nitrate

## DO PERCENT SATURATION

General rule for healthy streams



**Ozark Streams**  
> 80% DO Saturation



**Prairie or Lowland Streams**  
> 60% DO Saturation

Review QA/QC Temperature Dissolved Oxygen pH Conductivity Nitrate

## DISSOLVED OXYGEN KIT



Kit waste may be discarded on ground away from stream



If floc does not settle, wait 10 minutes and shake bottle again



Return unused, unopened DO 2 packets to Stream Team program

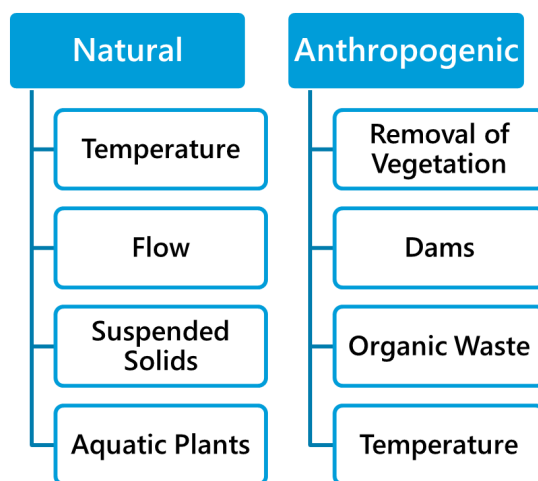
Review QA/QC Temperature Dissolved Oxygen pH Conductivity Nitrate

## Dissolved Oxygen

Under natural conditions, water generally can hold more than 5 mg/L of dissolved oxygen (DO). To determine what your DO reading means you should calculate percent saturation, which is temperature dependent. Oxygen is more easily dissolved in cold water than in warm water. Slow-moving warm-water prairie streams have will have a much lower saturation point than a fast-moving cool-water Ozark stream.

As a general rule, a healthy Ozark stream has greater than 80% DO saturation, while a healthy prairie or lowland stream will have greater than 60% DO saturation.

There are many influences on stream DO levels. Some of these are natural and some are anthropogenic, or human influenced:



## DO Troubleshooting

- Air bubble in sample bottle**—Try one of two methods to collect a sample:
  - Fill the sample bottle slightly into the frosted neck line. Add the DO 1 and 2 reagents, then stopper the bottle. This will result in a little spill-over but will not affect the test.
  - Place the sample bottle in the stream and stopper it while still under water. Remove the sample bottle from the stream and lift the stopper to add DO 1 and 2. A small amount of water that was pooled around the stopper will enter the sample bottle. This should be just enough water to prevent the air bubble when returning the stopper.
- Flocculant slow to settle**—Extremely cold water or high chloride levels will affect how the floc settles. If floc does not settle after 10 minutes, shake the bottle once more and continue with the test.
- Titration drops are small or inconsistent in size**—Hold dropper vertical and give confident, firm squeezes to ensure full drops. Release dropper bulb between drops. Do not allow drops to run down the side of the titration bottle.

## Measuring DO

1. Fill the dissolved oxygen bottle with sample water to the middle of the frosted area by submerging it in the stream.
2. Add the contents of one Dissolved Oxygen Reagent 1 packet and one Dissolved Oxygen Reagent 2 packet.
3. Stopper the bottle without trapping air bubbles.
4. Shake the bottle vigorously to mix.
5. Wait for flocculent to settle to approximately half the bottle volume.
6. Shake the bottle vigorously again.
7. Wait for the flocculent to settle to approximately half the bottle volume.
8. Remove the stopper and add the contents of one Dissolved Oxygen 3 Reagent powder pillow.
9. Stopper the bottle and shake the bottle vigorously (flocculent will dissolve and sample will turn yellow if oxygen is present).
10. Fill the plastic tube to the top with sample from dissolved oxygen bottle.
11. Place the square bottle over the full plastic tube and invert to pour the contents into the square bottle.
12. Add Sodium Thiosulfate Standard Solution one drop at a time to the mixing bottle (making sure to hold the dropper vertical). Count each drop. Swirl to mix after each drop. Add drops until the sample becomes colorless.
13. Record the number of drops used in Step 12. One drop equals one mg/L.

**DISSOLVED OXYGEN QC**

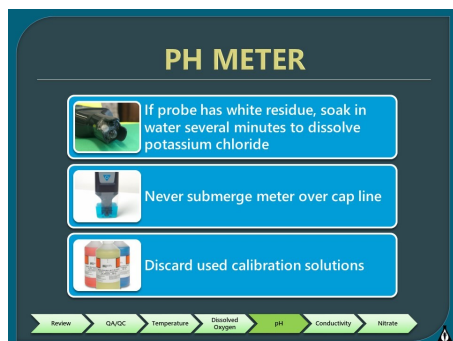
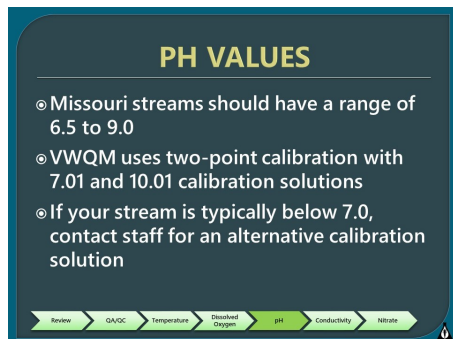
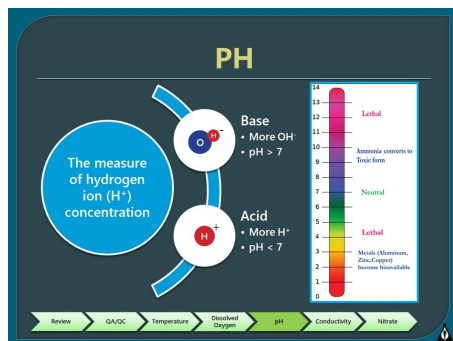
1. Measure the dissolved oxygen of the sample water on the table
2. Record result on the answer sheet

DO (mg/L)  (± 1.0 mg/L)

Review QA/QC Temperature Dissolved Oxygen pH Conductivity Nitrate

## DO QC

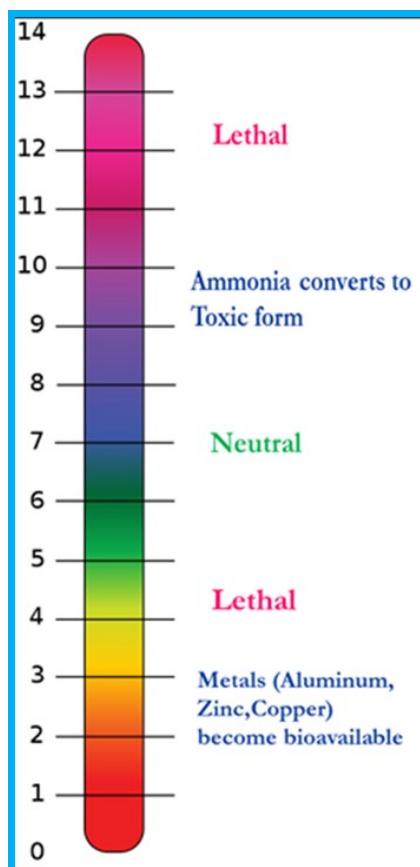
1. Measure the dissolved oxygen of the sample water on the table.
2. Record result on the answer sheet.



## pH

The pH levels of most Missouri streams should range from 6.5 to 9.0. Since the average pH of Missouri streams is slightly basic, we use a two-point calibration of 7.0 and 10.01. If typical pH readings for your stream site are below 7.0, please contact VWQM program staff for an alternative calibration solution.

pH levels above 10 and below 6 can be lethal to aquatic life. Lower pH allows sediments to release metals into the water, which can disrupt biological functions or cause deformities in fish.






## pH Troubleshooting


- White residue buildup on meter probe**—This white residue is potassium chloride. These meters are designed to slowly release potassium chloride to measure pH. To remove a buildup of residue from the meter, simply soak the meter in tap water or buffer solution and swirl. After calibration or measurement, store the meter in the cap with residual tap water or buffer solution. Do not store the pH meter in DI water.
- Air bubble in glass bulb**—The glass bulb is filled with an electrolyte solution. The electrolyte can move and shift during transport or horizontal storage. If an air bubble appears, shake the meter in a downward motion to force the bubble out of the glass bulb. Inspect the bulb for cracks and air bubbles prior to calibration.

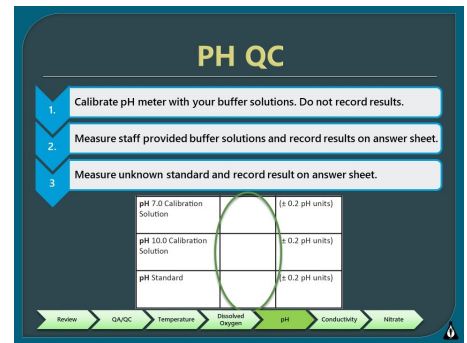
## Measuring pH

### Calibration (within 12 hours prior to monitoring):

1. Set the power to on and remove the cap from the sensor.
2. Push  to go to calibration mode. The auto-recognition standard (7.00) the tester expects will display at the bottom of the screen..
3. Pour the yellow pH 7.00 buffer solution into the cap to the fill line.
4. Put the sensor fully into the cap.
5. When the measurement is stable, push  to save the measurement. The measured value flashes three times.
6. Repeat steps 3-5 with blue pH 10.01 buffer solution.
7. Push and hold  to go to continuous measurement mode. "END" shows on the display.  
Note: "ECAL" shows on the display if the calibration was not successful.
8. Rinse the sensor and cap with deionized water and blot dry.

### Measurement:

1. Set the power to on.
2. Remove the cap from the sensor.
3. If the lock icon shows on the display, push  to go to continuous measurement mode.
4. Place meter sensor in flowing stream water until reading is stable.
5. The measured value shows on the top line.



## pH QC

1. Calibrate your pH meter with your pH 7 and pH 10 buffer solutions. Do not record these results from calibration.
2. Measure the staff provided pH 7 and pH 10 buffer solutions. Record these results on the answer sheet.
3. Measure the unknown standard. Record this result on the answer sheet.

### CONDUCTIVITY

- Measures how well an electrical current passes through water
- Dependent on amount of dissolved solids in water
  - Conductivity increases with increased ions (chloride, calcium, bicarbonate, etc.)
- Essential for biological functions

Review

QA/QC

Temperature

Dissolved Oxygen

pH

Conductivity

Nitrate

### AVERAGE CONDUCTIVITY

St. Francis mountains	30 – 150 $\mu\text{S}/\text{cm}$
Bootheel region	100 – 500 $\mu\text{S}/\text{cm}$
Ozark streams	150 – 500 $\mu\text{S}/\text{cm}$
Northern Missouri	300 – 800 $\mu\text{S}/\text{cm}$
Missouri/Mississippi River	500 – 800 $\mu\text{S}/\text{cm}$
Wastewater effluent	800 – 2000 $\mu\text{S}/\text{cm}$

Review

QA/QC

Temperature


Dissolved Oxygen

pH


Conductivity

Nitrate


### CONDUCTIVITY METER



If meter does not calibrate, soak in water with one drop of dish soap



Calibrate within 12 hours of sampling



If “- - - -” displays, the sample is over range

Review

QA/QC

Temperature

Dissolved Oxygen

pH

Conductivity

Nitrate

## Conductivity

Conductivity is the measurement of electrical current that can pass through water. This is dependent on dissolved solids, such as calcium, sodium, iron, and chloride. These dissolved solids form ions, which allow water to conduct electricity. Large amounts of dissolved solids in the stream results in higher conductivity readings.

Conductivity varies greatly from stream to stream. Below is a table of average conductivity readings in Missouri:



Stream location	Average conductivity
St. Francis mountains	30—150 $\mu\text{S}/\text{cm}$
Bootheel region	100—500 $\mu\text{S}/\text{cm}$
Ozark streams	150—500 $\mu\text{S}/\text{cm}$
Northern Missouri	300—800 $\mu\text{S}/\text{cm}$
Missouri/Mississippi River	500—800 $\mu\text{S}/\text{cm}$
Wastewater effluent	800—2000 $\mu\text{S}/\text{cm}$

## Conductivity Troubleshooting


- Unable to calibrate**—The electrodes probably need cleaned. These black platinum coated silver electrodes have a film coating from the manufacturer. Until the meter is well conditioned, this can interfere with calibration. Soak the meter in tap water with one drop of dish soap for several minutes, occasionally swirling. Do not wipe, rub or use abrasives on the probes.
- Meter displays “- - - -” while measuring conductivity**—Measurement is out of range. Low range conductivity meters can only measure up to 1990  $\mu\text{S}/\text{cm}$ . Conductivity measurements exceeding 1990  $\mu\text{S}/\text{cm}$  can be expected in large cities, such as St. Louis, Kansas City, and Springfield, during winter after road salt applications. If an out of range reading occurs and is unexpected for your stream site, contact VWQM program staff to report the high conductivity reading.

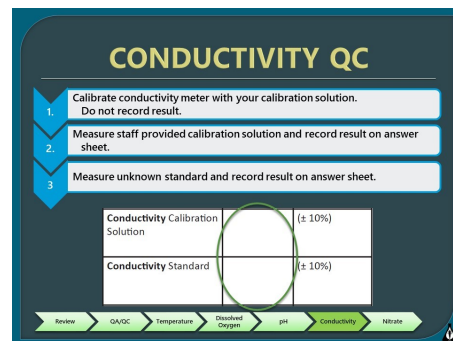
## Measuring Conductivity

### Calibration (within 12 hours prior to monitoring):

1. Set the power to on and remove the cap from the sensor.
2. Push  to go to calibration mode. The auto-recognition standard (1413 or 147  $\mu\text{S}/\text{cm}$ ) the tester expects will display at the bottom of the screen.
3. Pour the 1413  $\mu\text{S}/\text{cm}$  calibration standard shown into the cap to the fill line.
4. Put the sensor fully into the cap.
5. When the measurement is stable, push  to save the calibration and go to continuous measurement mode. The measured value will flash 3 times and then stop. Then, "END" shows on the display.
6. Rinse the sensor and cap with deionized water and blot dry.

### Measurement:

1. Set the power to on.
2. Remove the cap from the sensor.
3. If the lock icon shows on the display, push  to go to continuous measurement mode.
4. Place meter sensor in flowing stream water until reading is stable.
5. The measured value shows on the top line.



## Conductivity QC

1. Calibrate your conductivity meter with your calibration solution. Do not record this result from calibration.
2. Measure the staff provided calibration solution. Record this result on the answer sheet.
3. Measure the unknown standard. Record this result on the answer sheet.



## NITRATE

- Nitrogen measured as nitrate-nitrogen
- Occurs naturally and required by all organisms
- Excessive amounts overstimulates plant and algae grow

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

## NITRATE TEST KIT



Do not perform this test if pregnant



Always wear gloves and safety goggles



Containerize waste in a cubitainer

Review → QA/QC → Temperature → Dissolved Oxygen → pH → Conductivity → Nitrate

## Nitrate

VWQM measures nitrate as nitrogen ( $\text{NO}_3\text{-N}$ ). Nitrate levels are dependent on season, organic breakdown, and organic loading. Seasonally, nitrates are higher in the fall due to the organic breakdown of leaves and algae. Septic tanks, wastewater treatment plants, storm drains, feedlots, crop fields, and fertilized lawns can cause elevated nitrate levels. Average nitrate levels in Missouri range from less than 0.25 mg/L to 2.0 mg/L.



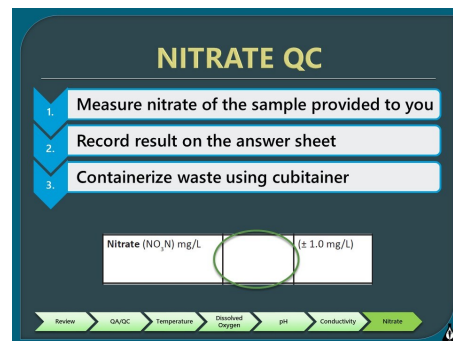
## Nitrate Troubleshooting

- **The solution looks yellow after completing the test** — Nitrate tablet #2 is sensitive to sunlight. Keep the test in the foil sleeve from the time tablet #2 is added until the test is complete. Exposing the test tube to sunlight will result in a yellow solution. A yellow solution may also be observed if nitrate is very low, despite not being exposed to sunlight. If you know your test tube was not exposed to sunlight during while running the test and you got a yellow solution, record your value as < 1 mg/L. If you think you may have exposed it to sunlight, rerun the test using the foil sleeve.
- **The solution looks stratified or cloudy after completing the test**—The tablets may not have dissolved. Be sure to shake the test tube vigorously with tablet #1 and tablet #2.
- **The reading is between two values on the colorimeter**—Record the nitrate reading as a range on the data sheet. For example, if the nitrate reading looks to be between 6 and 8 on the colorimeter, record this as, “>6 , <8.”



## Measuring Nitrate

1. Rinse the sample bottle three times with stream water.
2. Fill sample bottle with sample water.
3. Fill one test tube to the 5.0 mL line with water from the sample bottle.
4. Add one Nitrate #1 Tablet.
5. Cap and mix until the tablet disintegrates.
6. Place the test tube in foil protective sleeve.
7. Add one Nitrate #2 Tablet.
8. Cap the test tube and mix for (2) minutes to disintegrate the tablet.
9. Set a timer and wait (5) minutes
10. Remove the test tube from the foil protective sleeve
11. Inset the test tube into the Octa-Slide 2 Viewer (color comparator).
12. Hold the Viewer so that non-direct light enters through the back.
13. Match the sample color to a color on the Viewer.
14. Record the result on the data form as: NO<sub>3</sub>-N mg/L.
15. Record a range or number on the data form at NO<sub>3</sub>-N mg/L. *Do not use the multiplier on the instructions.*
16. Containerize the liquid waste in a waste container and pour down the drain after returning home.

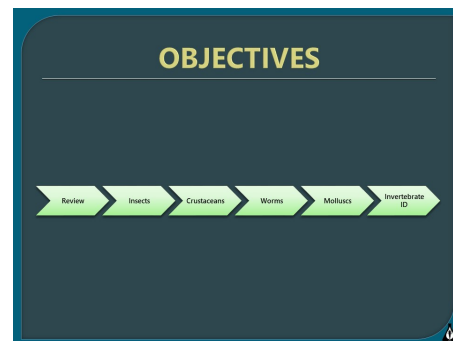


## Nitrate QC

1. Measure the nitrate of the sample provided to you.
2. Record result on the answer sheet.



# Aquatic Invertebrate ID



Benthic macroinvertebrates are identified to the taxonomic levels of class, order, or family under Stream Team VWQM protocol. These are the lowest level of identification easily accomplished without magnification. Various keys and identification tools can be used by a monitor until they are familiar with the organisms common in their stream. In this section we will cover:

- Biological sampling review
- Insect identification
- Crustacean identification
- Worm identification
- Mollusc identification
- Invertebrate identification quiz

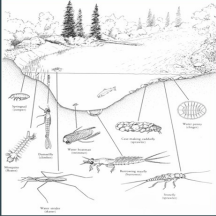
### FACTORS AFFECTING MACROINVERTEBRATES

- ◉ Dissolved Oxygen
- ◉ Toxic Chemicals
  - Acute toxicity (major pollution events)
  - Chronic toxicity (long term exposure at lower levels)
- ◉ Siltation
  - Increase turbidity
  - Increase embeddedness of substrate
- ◉ Habitat Loss
  - Channelization, dams, urban rip-rap, paving of urban streams

Review Insects Crustaceans Worms Molluscs Invertebrate ID

### STREAM MICROHABITATS

- ◉ Cobble-rock surface, interstitial spaces
- ◉ Fine sediment-silt, sand (burrowing species)
- ◉ Vegetation-aquatic plants, woody debris



Review Insects Crustaceans Worms Molluscs Invertebrate ID

### REMINDERS

- ◉ Collect samples in an upstream direction
- ◉ Do not collect from recently disturbed areas
- ◉ Be consistent

Review Insects Crustaceans Worms Molluscs Invertebrate ID

## Factors Affecting Macroinvertebrates

Many chemical and physical factors associated with stream quality can affect the structure and function of the macroinvertebrate community.

Loss of abundance and diversity are commonly attributed to:

- **Low Dissolved Oxygen**
- **Elevated Toxic Chemicals**
  - \* **Acute toxicity (major pollution events)**
  - \* **Chronic toxicity (long term exposure at lower levels)**
- **Increased Siltation**
- **Habitat loss due to channelization, dams, and urbanization**
- **Increased embeddedness of substrate**
- **Habitat Loss**
- **Channelization, dams, urban rip-rap, paving of urban streams**

## Stream Microhabitats

You are encouraged to sample macroinvertebrates by collecting three net sets from riffle macrohabitat, although rootmat and woody debris macrohabitats can be used if riffles are not present. By collecting each net set from a microhabitat within the riffle you can increase the diversity of your sample. Microhabitats are created by:

- **Interstitial spaces between gravel and cobble**
- **Fine sediment accumulations towards the stream edge**
- **Fast or slow current**
- **Shallow or deeper water**
- **Vegetation**

## Sampling Reminders

Regardless of the macrohabitat that you sample, there are several guidelines that you should apply:

- **Always collect samples in an upstream direction**
- **Do not sample in areas that you have disturbed**
- **Be consistent**

## Specimen Preservation

Solution	Pros	Cons	Comments
30% Isopropyl	Inexpensive and can be found at most general retailers	Harsh on invertebrates-will make them brittle over time	<ul style="list-style-type: none"> <li>•Buffer with 1-2 drops of glycerin</li> <li>•Sold in 70% and 90% concentrations.</li> </ul>
80% Ethyl alcohol (Denatured alcohol)	Best method for long term storage-less harsh on specimens  Less harsh on specimens	More expensive and difficult to find	<ul style="list-style-type: none"> <li>•Buffer with Tums</li> <li>•Kleen Strip Green Denatured Alcohol</li> <li>•Often near paint supplies</li> <li>•Make sure product is mostly ethyl alcohol, not methanol</li> </ul>
Hand Sanitizer	Suspends specimens for viewing	Not recommended for large or soft inverts as it's only 60% alcohol	<ul style="list-style-type: none"> <li>•Gel must be replenished over time as it breaks down into a liquid</li> <li>•Specimen must be euthanized before being placed in gel</li> </ul>

SPECIMEN PRESERVATION			
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NUISANCE SPECIES PREVENTION				
Technique	Duration	Concentration	Solution	Comments
Vinegar	20 min.	100%	1 gallon of vinegar, no water	Safety glasses and gloves should be worn. Corrosive to metal and toxic to fish.
Chlorine (6% household bleach)	10 min.	3%	4 oz of bleach and 1 gallon of water	Before re-use rinse with water but don't let the solution runoff directly to the stream.
Air Drying	3-5 days	NA	NA	Equipment must dry completely.
Freezing < 32°F	24 hours	NA	NA	Must be below freezing for duration of contact time.
Salt Bath	24 hours	1%	1/8 cup in 1 gallon of water	Equipment must be completely submerged.

## Nuisance Species Prevention

Technique	Duration	Concentration	Solution	Comments
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Air Drying	3-5 days	NA	NA	Equipment must dry completely.
Freezing < 32°F	24 hours	NA	NA	Must be below freezing for duration of contact time.
Salt Bath	24 hours	1%	1/8 cup in 1 gallon of water	Equipment must be completely submerged.

TAXONOMIC LEVELS WITH  
EXAMPLE

Kingdom

• Animalia

Phylum

• Arthropoda

Class

• Insecta

Order

• Ephemeroptera

Family


• Heptageniidae

Genus

• Stenonema

Species

• femoratum



MDC photo

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID

VWQM TAXA

Class

• Gilled snail, mussel, aquatic worm, leech, other snail

Order

• Caddisfly, mayfly, stonefly, crayfish, scud, sowbug, other beetle larva

Sub-Order

• Dragonfly, damselfly

Family

• Riffle beetle, water penny, crane fly, alderfly, watersnipe fly, midge, pouch snail

Genus

• Hellgrammite, fishfly

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID

## Taxonomic Levels

Taxonomic levels refer to the organization of macroinvertebrate names that are based on the Linnaeus taxonomic classification system. This naming system is hierarchical, with the broadest grouping starting at “Kingdom” and the narrowest grouping ending at “Species.” The complete system in descending order is: Kingdom, Phylum, Class, Order, Family, Genus, Species. Listed below are the classification groups and common names that the VWQM Program uses for macroinvertebrate identification.

### Class

- Gilled snail, mussel, aquatic worm, leech, other snail

### Order

- Caddisfly, mayfly, stonefly, crayfish, scud, sowbug, other beetle larva

### Sub-Order

- Dragonfly, damselfly

### Family

- Riffle beetle, water penny, crane fly, alderfly, watersnipe fly, midge, pouch snail

### Genus

- Hellgrammite, fishfly







MAYFLY

(EPHEMEROPTERA)

- Three major body regions: head, thorax and abdomen
- Short antennae
- Six legs with one sharp claw on each foot
- One visible pair of wing pads on top of thorax
- Gills on top and sides of abdomen
- Three tails (some have two)
- ¼"-1" in length (not including tail),

Review

Insects

Crustaceans

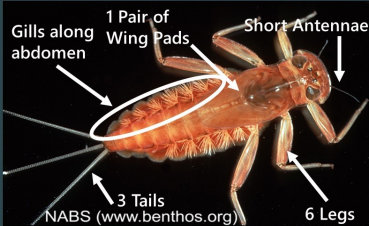
Worms

Molluscs

Invertebrate ID

MAYFLY

(EPHEMEROPTERA)



Review

Insects

Crustaceans

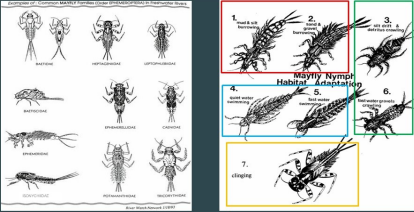
Worms

Molluscs

Invertebrate ID

MAYFLY

(EPHEMEROPTERA)



Review



Insects



Crustaceans

Worms

Molluscs

Invertebrate ID

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID

# Insects: Mayfly (Ephemeroptera)

## A checklist of important mayfly characteristics:

- Three recognizable major body regions (head, thorax and abdomen)
- Short antennae
- Thorax has six jointed legs with one sharp claw on each foot
- One visible pair of wing pads on top of thorax
- Gills attach to sides of abdomen
- Three tails at the end of the abdomen (some have two)
- ¼"-1" in length (not including tail)

## Some useful behavioral characteristics:

- Some are good swimmers
- Others are crawlers
- Mayfly gills may be more visible when the mayfly is at rest in water





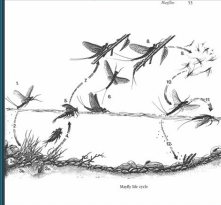
## Insects: Mayfly (Ephemeroptera)

### Life history details:

- Nymphs live in riffles, sand, or mud burrows for months or years eating mostly algae, detritus, etc.
- Nymphs molt to a terrestrial sub-imago stage, which quickly molts again to mature imago stage
- Emergence of adults may be synchronized
- Adults live for hours or days, mate, and lay eggs on water surface
- In healthy ecosystems, adults of some species can create massive swarms during emergence




**MAYFLY (EPHEMEROPTERA)**



- Nymphs live in riffles or in sand or mud burrows for months or years eating mostly algae, detritus, etc.
- Molts to terrestrial sub-imago stage, which quickly molts again to mature imago stage
- Emergence of adults may be synchronized
  - Adults live for hours or days, mate, and lays eggs on water surface

Review Insects Crustaceans Worms Molluscs Invertebrate ID

**MAYFLY (EPHEMEROPTERA)**





- In healthy ecosystems, adults of some species can create massive swarms during emergence

MDC photo MDC photo (8/10/2004)

Review Insects Crustaceans Worms Molluscs Invertebrate ID

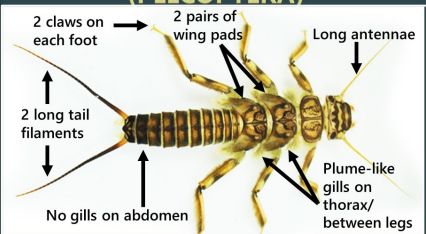
### STONEFLY (PLECOPTERA)

- Three major body regions: head, thorax, and abdomen
- Two long bristle-like antennae
- Six legs with two claws on each foot
- Two pairs of large wing pads on thorax
- Might have plume-like gills on thorax between the legs (hairy armpits), abdomen gill-less
- Two bristle-like tails
- 1/8"-1 1/2" long

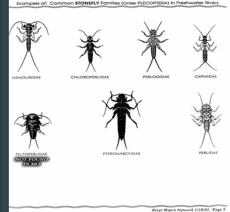
Review Insects Crustaceans Worms Molluscs Invertebrate ID

### STONEFLY (PLECOPTERA)







Review Insects Crustaceans Worms Molluscs Invertebrate ID

### STONEFLIES (PLECOPTERA)



- There are multiple families of stonefly
- Various shapes and ecological niches and diets

Review Insects Crustaceans Worms Molluscs Invertebrate ID

Review Insects Crustaceans Worms Molluscs Invertebrate ID

## Insects: Stonefly (Plecoptera)

### A checklist of important stonefly characteristics:

- Three recognizable major body regions (head, thorax, and abdomen)
- Two long bristle-like antennae
- Thorax has six jointed legs with two claws on each foot
- Two pairs of wing pads on thorax
- Might have plume-like gills on thorax between the legs (hairy armpits), abdomen without gills
- Two bristle-like tails
- 1/8"-1 1/2" long

### Some useful behavioral characteristics:

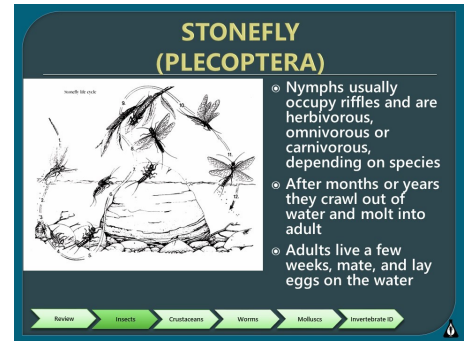
- All are crawlers



## Insects: Stonefly (Plecoptera)


### Life history details:

- Nymphs can be common in riffles and are herbivorous, omnivorous or carnivorous, depending on species
- After months or years they crawl out of water and molt into adult
- Adults live a few weeks, mate, and lay eggs on the water



### CADDISFLY (TRICHOPTERA)


- Three major body regions: head, thorax and abdomen; the head and thorax are much darker and harder than abdomen. Hairy body overall
- Larvae up to 1"
- Three pair of legs
- May have filamentous gills on underside of abdomen.
- The end of abdomen will have a pair of prolegs with hooks at the end
- Larvae have no wing pads and have a very definite grublike or wormlike appearance
- Posterior end of abdomen will usually form a slight crook.



MDC photo  
Caddisfly adult  
MDC photo

Review Insects Crustaceans Worms Molluscs Invertebrate ID

### CADDISFLY (TRICHOPTERA)



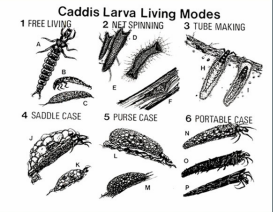
Exoskeleton harder and darker on thorax and head  
Soft, grub-like abdomen  
Pair of prolegs at end of abdomen  
Filamentous gills under abdomen  
6 Legs

NABS (www.benthos.org)

Review Insects Crustaceans Worms Molluscs Invertebrate ID

### CADDISFLY (TRICHOPTERA)

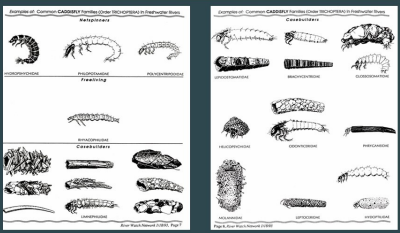
**Caddis Larva Living Modes**



- Free living
- Net spinning
- Tube making
- Saddle case
- Purse case
- Portable case

Review Insects Crustaceans Worms Molluscs Invertebrate ID

### CADDISFLY (TRICHOPTERA)



Review Insects Crustaceans Worms Molluscs Invertebrate ID

## Insects: Caddisfly (Trichoptera)

### A checklist of important caddisfly characteristics:

- Three major body regions (head, thorax and abdomen)
- The head and thorax are much darker and harder than abdomen
- The abdomen may be hairy
- Thorax has six jointed legs
- May have filamentous gills on underside of abdomen.
- The end of abdomen will have a pair of prolegs with single hooks at the end
- Larvae have no wing pads and have a very definite grublike or wormlike appearance
- Larvae up to 1"

### Some useful behavioral characteristics:

- All are crawlers, but they may try to pull themselves backwards using their abdominal prolegs
- May be free-living, net-spinning, or case makers

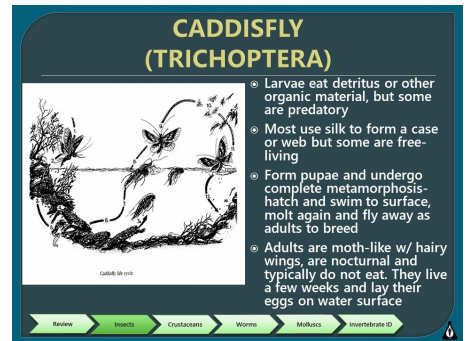




## Insects: Caddisfly (Trichoptera)


### Life history details:

- Larvae eat detritus or other organic material, but some are predatory
- Most use silk to form a case or web but some are free-living
- Form pupae and undergo complete metamorphosis, hatch and swim to surface, molt again, and fly away as adults to breed
- Adults are moth-like with hairy wings, are nocturnal, and typically do not eat. They live a few weeks and lay their eggs on water surface or crawl underwater to lay eggs



### DOBSONFLY, FISHFLY, ALDERFLY (MEGALOPTERA)


- Larvae are elongate and slightly flattened
- Head possesses large mandibles
- Head and thorax are harder than abdomen
- Thorax has six legs
- Abdominal segments each have a pair of lateral filaments



Review Insects Crustaceans Worms Molluscs Invertebrate ID


### DOBSONFLY/HELLGRAMMITE (MEGALOPTERA)

- Very large mandibles capable of a painful pinch
- Has conspicuous gill tufts under lateral filaments
- Very large, up to 4"



Review Insects Crustaceans Worms Molluscs Invertebrate ID

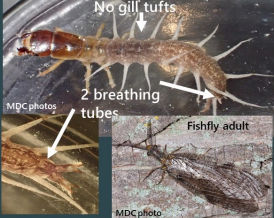
### DOBSONFLY/HELLGRAMMITE (MEGALOPTERA)



Review Insects Crustaceans Worms Molluscs Invertebrate ID

### FISHFLY (MEGALOPTERA)


- Very similar to hellgrammite
- Has no gill tufts on abdomen
- 2 breathing tubes at end of abdomen



Review Insects Crustaceans Worms Molluscs Invertebrate ID

### ALDERFLY (MEGALOPTERA)

- Similar to fishfly and dobsonfly but often smaller
- No gill tufts under filaments
- Abdomen ends in a single long feathery filament
- Rarely collected by VWQM methods



Review Insects Crustaceans Worms Molluscs Invertebrate ID

## Insects: Dobsonfly, Fishfly, Alderfly (Megaloptera)

Dobsonflies, fishflies, and alderflies belong to the Order Megaloptera. However, each can be easily identified and are separately recorded on the VWQM macroinvertebrate datasheet.

### A checklist of important dobsonfly, fishfly, and alderfly characteristics:

- Larvae are elongate and slightly flattened
- Head possesses large mandibles
- Head and thorax are harder than abdomen
- Thorax has six jointed legs
- Abdominal segments each have a pair of lateral filaments

### A checklist of additional Dobsonfly characteristics:

- Conspicuous gill tufts under lateral filaments
- Prolegs at the end of the abdomen with two claws on the end

### A checklist of additional fishfly characteristics:

- Does not have gill tufts under lateral filaments
- Two breathing tubes near the end of abdomen
- Prolegs at end of the abdomen with two claws on the end

### A checklist of additional alderfly characteristics:

- Does not have gill tufts under lateral filaments
- Abdomen ends in a single long feathery filament

## Insects: Dobsonfly, Fishfly, Alderfly (Megaloptera)

### Some useful behavioral characteristics:

Alderfly are widespread in Missouri (see red dots on graphic below) but are rarely collected by VWQM methods. MoDNR data shows that when they are collected : 80% are found in pools; 25% are found on rootmat; 9% are found in riffles; and 4% are found on woody debris.

### Life history details:

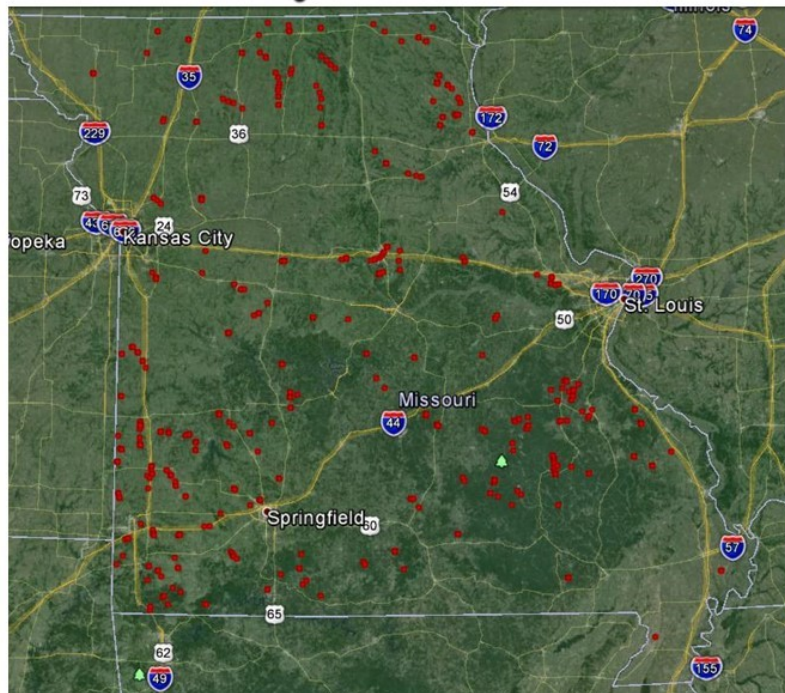
- Larvae are mostly predatory, feeding on other invertebrates or even small fish
- Larvae live in water for as long as 2-3 years
- Hellgrammites are often found in riffles, while fishflies and alderflies can be found in slower water among organic debris or in rootmat
- Larvae crawl out of water to pupate on land
- Adults live days to a week and do not eat. They are often nocturnal and are poor fliers
- Females lay eggs on vegetation overhanging water

### DOBSONFLY, FISHFLY, ALDERFLY (MEGALOPTERA)

- Larvae are mostly predatory, feeding on other invertebrates or even small fish
- Larvae live in water for as long as 2-3 years
- Hellgrammites are often found in riffles, while fishflies and alderflies can also be found in slower water among organic debris or silt
  - Larvae crawl out of water to pupate on land
- Adults live days to a week and do not eat.
  - They are often nocturnal and are poor fliers
  - Females lay eggs on vegetation overhanging water

Review Insects Crustaceans Worms Molluscs Invertebrate ID


## Alderfly Distribution





### FLY (DIPTERA)

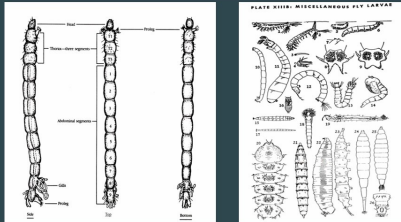
- Very diverse group, many with aquatic larvae
- Adult forms are highly variable, but always have only one pair of wings (other insects have two)
- Larvae are usually elongate and maggot-like
  - Head may or may not be well developed and conspicuous
  - Eyes are poorly developed
  - Wing pads are absent
  - Thorax never possesses three pairs of segmented legs, but prolegs may be present near head or on abdomen



MDC photo

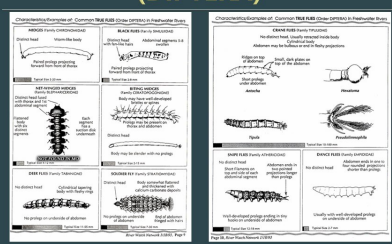
Review Insects Crustaceans Worms Molluscs Invertebrate ID

### FLY (DIPTERA)



Review Insects Crustaceans Worms Molluscs Invertebrate ID

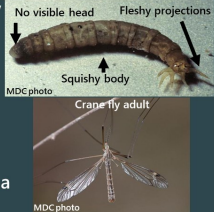
### FLY (DIPTERA)



Review Insects Crustaceans Worms Molluscs Invertebrate ID

### CRANE FLY (DIPTERA)

- Larvae can be up to 4"
- Very soft-bodied
- Abdomen ends in flattened plate, projections, or is bulbous
- Larvae very mobile
- Adults don't eat, or drink nectar and have a short lifespan



MDC photo

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## Insects: Fly (Diptera)

Diptera are a very diverse group; many have aquatic larvae. Fly larvae can be found in almost any aquatic environment, with some, such as midges and mosquitoes, being capable of living in extremely stagnant or polluted water. Most aquatic fly larvae are generalists and feed on detritus or any organic materials, but some are predatory. Adult forms are also highly variable, but always have only one pair of wings (other insects have two).

### A checklist of important fly characteristics:

- Larvae are usually elongate and maggot-like
- Head capsule may or may not be well developed and conspicuous
- Eyes are poorly developed
- Wing pads are absent
- Thorax never possesses jointed legs, but fleshy prolegs may be present near head or on abdomen

### A checklist of additional crane fly characteristics:

- Larvae can be up to 4" long
- Very soft-bodied
- Abdomen ends in flattened plate, projections, or is bulbous
- No distinct head

### A checklist of additional watersnipe fly characteristics:

- Abdomen ends in 2 horn-like projections
- No distinct head

### A checklist of additional midge fly characteristics:

- Prolegs behind head and at end of abdomen
- Most are very small (<1/2")
- Some larvae are red or pinkish (bloodworms); others are green or clear
- Have a hard, distinctive head capsule



## Insects: Fly (Diptera)

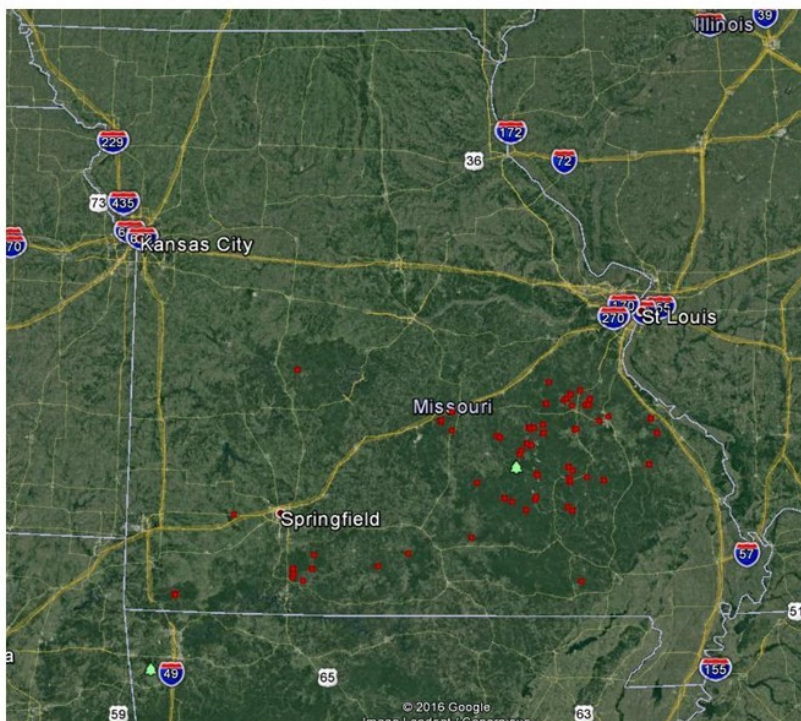
### A checklist of additional black fly characteristics:

- Larvae small (<1/2")
- Have a distinct head capsule
- Have a proleg behind the head capsule
- Have a distinctive "bowling pin" shape

### Some useful behavioral and life history characteristics:

- Although crane fly larvae do not have segmented legs they can be very mobile and "crawl" well
- Watersnipe flies move like a caterpillar with its prolegs
- Watersnipe flies are not widely distributed in Missouri. They are restricted to cool water streams in the Ozarks (see red dots on the distribution map below)
- Midge fly larvae slowly crawl and when suspended in water will generally "flip" and "twitch" in jerky motions
- Black fly larvae stick to surfaces with the end of their abdomen

## Watersnipe Fly Distribution



### WATERSNIPE FLY (DIPTERA)

- Abdomen ends in 2 horn-like projections
- No distinct head
- Moves like a caterpillar with its prolegs
- Rare in Missouri

Feathery horns  
Visible prolegs  
NABS (www.benthos.org)  
Watersnipe fly adult  
Wiki Commons

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### HORSE/DEER FLY (DIPTERA)

- Larvae similar to watersnipe fly
  - lacks horns and has prolegs or creeping welts that circle the body
- Larvae very mobile
- Up to 1 1/2" long
- Larvae are predatory or eat detritus.
- Adults feed on nectar/pollen and females also feed on blood to produce eggs

Creeping welts  
MDC photo  
Horsefly adult  
MDC photo

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### MIDGE (DIPTERA)

- No jointed legs, only prolegs behind head and at end of abdomen
- Most are very small (<1/2")
- Some larvae are red or pinkish (bloodworms)
- J-shaped when preserved
- Adults often swarm and rarely eat

prolegs  
NABS (www.benthos.org)  
Adult Midge  
MDC photo

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### BLACK FLY (DIPTERA)

- Larvae small (<1/2")
- Stick to surfaces with their abdomen
- Filter feed using feathery mouthparts
- Pupae stick to surfaces too and have thread-like tassels
- Adult females feed on blood to produce eggs

Feathery mouthparts  
Suction disc  
Steve Marshall  
Black Fly pupae  
MDC photo  
NABS photo

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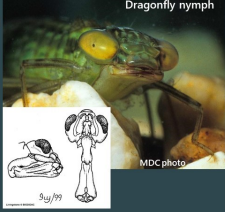
### FLIES (DIPTERA)

- Most aquatic fly larvae are generalists and feed on detritus or any organic material. They are also often very low on the aquatic food chain
- Fly larvae can be found in almost any aquatic environment, with some, such as midges and mosquitoes, being capable of living in extremely stagnant or polluted water
- Pupae highly variable; may be free-living or sedentary and have gills or breathe air
- Adults either don't eat, feed on nectar or other plant juices, drink blood, or are predatory

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### DRAGONFLY AND DAMSELFLY (ODONATA)

- Six long legs
- Two very large compound eyes
- A extendable labium (mouth) that is hinged and designed to grab prey. It is folded under the head and thorax
- No gills, plumes, or hair-like projections on the abdomen or thorax
- Length ranges from 1/4"-2"



Dragonfly nymph


MDC photo

5/11/19

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### DRAGONFLY (ODONATA)


- No tail or outer surface gills
- Wide, oval to round abdomen
- Nymphs can jet propel by expelling water from their rectum



Wide abdomen

No tail


MDC photo



Dragonfly adult

MDC photo

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## Insects: Dragonfly, Damselfly (Odonata)

Dragonfly and damselfly nymphs are aggressive predators, using their labium to catch prey as large as amphibians and even small fish.

### A checklist of important dragonfly and damselfly characteristics:

- Three major body regions (head, thorax and abdomen)
- Thorax has six jointed legs
- Two large compound eyes
- An extendable labium (lower lip) that is hinged and designed to grab prey. It is folded under the head and thorax
- No gills, plumes, or hair-like projections on the abdomen or thorax
- Length ranges from 1/4"-2"

### A checklist of additional dragonfly characteristics:

- No tail or outer surface gills
- Wide, oval to round abdomen

### A checklist of additional damselfly characteristics:

- Three large, paddle-like tails (actually tracheal gills)
- Abdomen long and slender and thorax very short and wider with very tightly folded, high, dorsal wing cases





## Insects: Dragonfly, Damselfly (Odonata)

### Some useful dragonfly and damselfly behavioral characteristics:

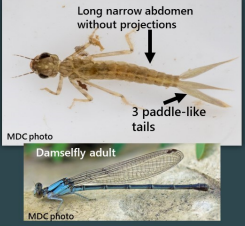
- Dragonfly nymphs can jet propel by expelling water from their rectum
- Damselfly nymphs can swim by undulating their bodies

### Life history details for dragonfly and damselfly:

- Nymphs commonly occur in still water or stream edges clinging to aquatic vegetation or rootmat, but some nymphs are bottom-dwelling
- Nymphs can stay in water for 1-2 years, depending on species and environment
- Nymphs crawl out of water for their final molt to become adults
- Adults eat flying insects (midges, mosquitoes, etc.)
- Mating pairs fly in tandem
- Females lay eggs in water

### DAMSELFLY (ODONATA)

- Three large, paddle-like tails that are actually tracheal gills
- Abdomen long and slender and thorax very short and wider with very tightly folded, high, dorsal wing cases
- Nymphs can swim by undulating their bodies



Long narrow abdomen without projections

3 paddle-like tails

MDC photo

Damselfly adult

MDC photo

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MDC photo

MDC photo

MDC photo

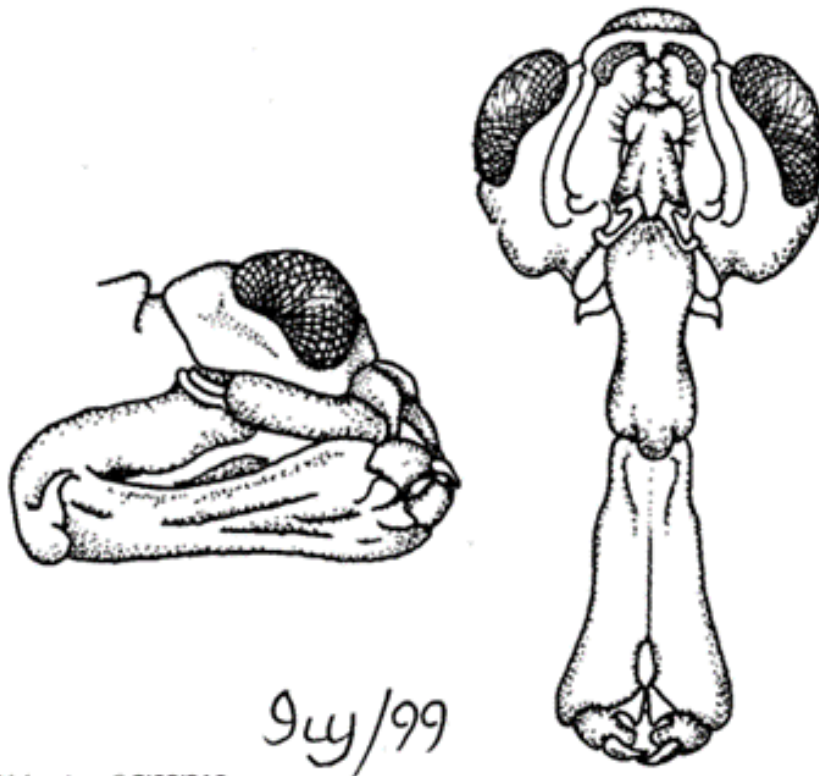
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### DRAGONFLY AND DAMSELFLY (ODONATA)

- Nymphs are aggressive predators, using their labium to catch prey as large as amphibians & small fish
- Damselfly and many dragonfly nymphs occur in still water or stream edges clinging to aquatic vegetation or root mats, but some dragonfly nymphs are bottom-dwelling
  - Nymphs can stay in water for years depending on species and environment
  - Nymphs crawl out of water for their final molt to become adults
- Adults eat flying insects (midges, mosquitoes, etc.)
  - mating pairs fly in tandem
  - Females lay eggs in water


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Livingstone © BIODIDAC

### BEETLE (COLEOPTERA)

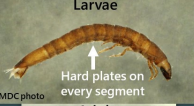

- Most diverse group of animals, but most are fully terrestrial
- Adults are hard-bodied, oval to elongate
  - Head possesses chewing mouthparts, well-developed eyes, and variably shaped antennae
  - Fore wings are modified into hardened covers (elytra) over the abdomen and the hind wings
- Larvae are variously shaped and measure ¼"-1" at maturity
  - Head is usually distinct in larvae and possesses chewing mouthparts
  - Wing pads are absent on larvae
  - Thorax has 6 well-developed legs
  - Abdomen may possess lateral and/or terminal filaments, tail-like structures, gills



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### RIFFLE BEETLE (COLEOPTERA)



- Very small, 3/8"
- Larvae are grub-like but covered with hard plates over entire body
- Adults are dark colored and slow crawling
- Both larvae and adult are aquatic and feed on algae/detritus

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### WATER PENNY (COLEOPTERA)

- Very dorsally flattened and saucer-shaped
- Segmented body with legs underneath
- Moves slowly, clinging to rock surfaces in riffles to feed on algae
- Adults are terrestrial

Review Insects Crustaceans Worms Molluscs Invertebrate ID

## Insects: Beetle (Coleoptera)

Beetles are the most diverse group of animals, but most are fully terrestrial.

### A checklist of important beetle characteristics:

#### Adults

- Hard-bodied, oval to elongate
- Head possesses chewing mouthparts, well-developed eyes, and variably shaped antennae.
- Fore wings are modified into hardened covers (elytra) over the abdomen and the hind wings

#### Larvae

- Variably shaped and measure ¼"-1" at maturity
- Head is usually distinct in larvae and possesses chewing mouthparts
- Wing pads are absent on larvae.
- Thorax has six jointed legs
- Abdomen may possess lateral and/or terminal filaments, tail-like structures, gills

### A checklist of additional riffle beetle characteristics:

- Very small, ~3/8"
- Larvae are covered with hard plates over entire body
- Adults are dark colored with fairly long legs

### A checklist of additional water penny characteristics:

- Very dorsally flattened and saucer-shaped
- May have gills on the abdomen

### A checklist of additional Other Beetle characteristics:

- Larvae are variously shaped (some have lateral projections)
- Adults are generally oval and convex

## Insects: Beetle (Coleoptera)

### Some useful beetle behavioral characteristics:

- Adult riffle beetles are slow crawlers
- Water penny larvae crawl slowly, clinging to rock surfaces in riffles

### Life history details for beetles:

- Both larvae and adult riffle beetles are aquatic and feed on algae/detritus
- Water penny larvae scrape algae off rocks
- Water penny adults are terrestrial
- Species are highly variable but aquatic larvae tend to be benthic
- Diet variable; may feed on algae/detritus (riffle beetles and water penny larvae), or may be aggressive predators of other insects and small fish (predacious diving beetles and whirligig beetles)
- All go through a pupal stage to become adults
- Adults of many aquatic beetle species trap air bubbles to their abdomen via specialized structures on their exoskeleton to breathe under water for short periods
- The adults of aquatic beetles are generally capable of flight and many are powerful swimmers
- Some species prefer riffles but many others prefer still water habitats like pools, ponds, and stream edges

### OTHER BEETLES (COLEOPTERA)

- There are many other aquatic beetles
- Larvae are variously shaped
- Adults are generally oval and convex
- Adults may swim underwater or on the surface, or crawl on the bottom
- Herbivorous, omnivorous, or carnivorous depending upon species and life stage

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Predacious diving beetle larvae  
Water scavenger beetle larvae  
Whirligig beetle larvae  
Predacious diving beetle  
Water scavenger beetle  
Whirligig beetle

MDC photo MDC photo MDC photo MDC photo MDC photo MDC photo

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### BEETLE (COLEOPTERA)


- Species are highly variable but aquatic larvae tend to be benthic
- Diet variable; may feed on algae/detritus (riffle beetles and water penny larvae), or may be aggressive predators of other insects and small fish (predacious diving beetles and whirligig beetles)
- All go through a pupal stage to become adults
- Adults of many aquatic beetle species trap air bubbles to their abdomen via specialized structures on their exoskeleton to breathe under water for short periods
- The adults of aquatic beetles are generally capable of flight and many are powerful swimmers too
- Some species prefer riffles but many others prefer still water habitats like pools, ponds, and stream edges

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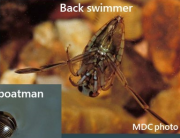



### TRUE BUG (HEMIPTERA)

- Very diverse, but all have a straw-like beak (proboscis), 6 legs, and large eyes. Many have raptorial forearms and wings as adults
- Nymphs closely resemble adults
- Aquatic species are generally predatory and inject venom and digestive enzymes into their prey and drink its fluids through their beak
- May be at or just below water surface or clinging to aquatic vegetation in still or shallow water
- Usually air-breathing, some breathe out of tubes on their abdomen like a snorkel



Giant Water Bug  
MDC photo

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## Insects: True Bug (Hemiptera)

### A checklist of important true bug characteristics:

- Very diverse, but all have a straw-like beak (proboscis)
- Thorax has six jointed legs
- Have large eyes
- Many have raptorial forearms
- Most adults are winged

### Some useful true bug behavioral characteristics:

- Some are very good swimmers
- Many are slow crawlers

### Life history details for true bugs:

- Nymphs closely resemble adults
- Aquatic species are generally predatory and inject venom and digestive enzymes into their prey and drink its fluids through their beak
- May be at or just below water surface or clinging to aquatic vegetation in still or shallow water
- Usually air-breathing, some breathe out of tubes on their abdomen like a snorkel





## Insects: Aquatic Caterpillar (Lepidoptera)

A few species of moths have aquatic larvae

### A checklist of important aquatic caterpillar characteristics:

- Larvae resemble terrestrial caterpillars
- Long body
- Chewing mandibles
- Thorax has six short jointed legs,
- Have several abdominal prolegs
- May have filamentous gills covering body

### Some useful aquatic caterpillars behavioral characteristics:

- Are found around aquatic vegetation

### Life history details for aquatic caterpillars:

- Adults are terrestrial and resemble a typical moth



### AQUATIC CATERPILLAR (LEPIDOPTERA)

- A few species of moths have aquatic larvae
- Larvae resemble terrestrial caterpillars; long body, chewing mandibles, 6 developed legs, and several abdominal prolegs
- May have filamentous gills covering body
- Are found around aquatic vegetation
- Adults are terrestrial and resemble a typical moth

Review
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### CRAYFISH (DECAPODA)


- Easily recognized (looks like small lobster)
- Can be found in most aquatic environments
  - Some hide under boulders or cobble, or dig burrows in mud, silt, or gravel
- Will eat virtually anything from algae, detritus, and vegetation to live invertebrates, fish, and carrion
- Very diverse in Mo-35 species including 7 endemic species
- The Ozarks have some of the highest densities of crayfish on Earth

Crayfish play a very important role in stream ecosystems, linking benthic food webs to larger animals such as bass, otters, raccoons, herons, hellbenders, etc.

Golden crayfish  
MDC photo


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Northern crayfish




MDC photo

Painted crayfish




MDC photo

Freckled crayfish



MDC photo

Belted crayfish



MDC photo

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## Crustaceans: Crayfish (Decapoda)

### A checklist of important crayfish characteristics:

- Thorax has eight jointed walking legs
- Thorax has two modified legs with claws
- Easily recognized (looks like small lobster)

### Some useful crayfish behavioral characteristics:

- Can be found in most aquatic environments, usually hide under boulders or cobble, or dig burrows in mud, silt, or gravel

### Life history details for crayfish:

- Will eat virtually anything from algae, detritus, and vegetation to live invertebrates, fish, and carrion
- Very diverse in Missouri (35 species including 7 endemic species)
- The Ozarks have some of the highest densities of crayfish on Earth
- Crayfish play a very important role in stream ecosystems, linking benthic food webs to larger animals such as bass, otters, raccoons, herons, hellbenders, etc.



## Crustaceans: Scud (Amphipoda)

### A checklist of important scud characteristics:

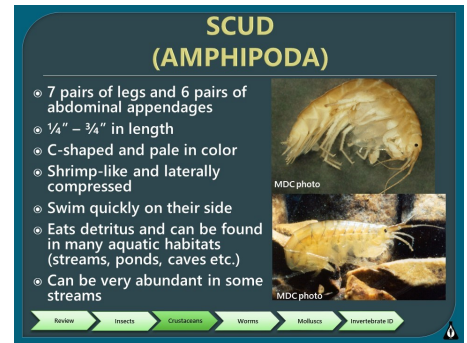
- Thorax has seven pairs of jointed legs
- Abdomen has six pairs of appendages
- $\frac{1}{4}$ " –  $\frac{3}{4}$ " in length
- Pale in color
- Shrimp-like and laterally compressed

### Some useful scud behavioral characteristics:

- Very good swimmers

### Life history details for scuds:

- Eat detritus and can be found in many aquatic habitats (streams, ponds, caves, etc.)
- Can be very abundant in some streams



**SOWBUG  
(ISOPODA)**

- Very similar to pill bugs (rollie- pollies)
- 7 pairs of legs
- Dorsally flattened
- $\frac{1}{4}$ " -  $\frac{3}{4}$ " in length
- Generally found hiding between rocks and under debris in streams, cave pools, etc.
- Feeds on organic debris such as dead leaves
- Can be very abundant in some streams

MDC photo

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## Crustaceans: Sowbug (Isopoda)

### A checklist of important sowbug characteristics:

- Very similar to terrestrial pill bugs (roly poly)
- Seven pairs of jointed legs
- Dorsally flattened
- $\frac{1}{4}$ " -  $\frac{3}{4}$ " in length

### Some useful sowbug behavioral characteristics:

- Crawlers

### Life history details for sowbugs:

- Generally found hiding between rocks and under debris in streams, cave pools, etc.
- Feed on organic debris such as dead leaves
- Can be very abundant in some streams



## Worms: Horsehair Worm (Nematomorpha)

### A checklist of important horsehair worm characteristics:

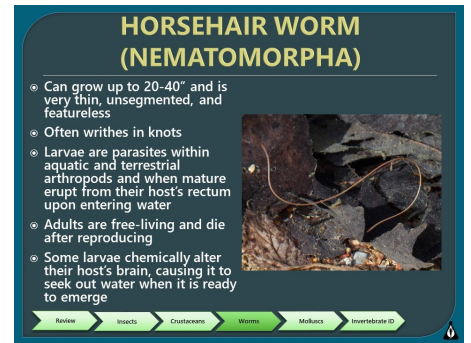
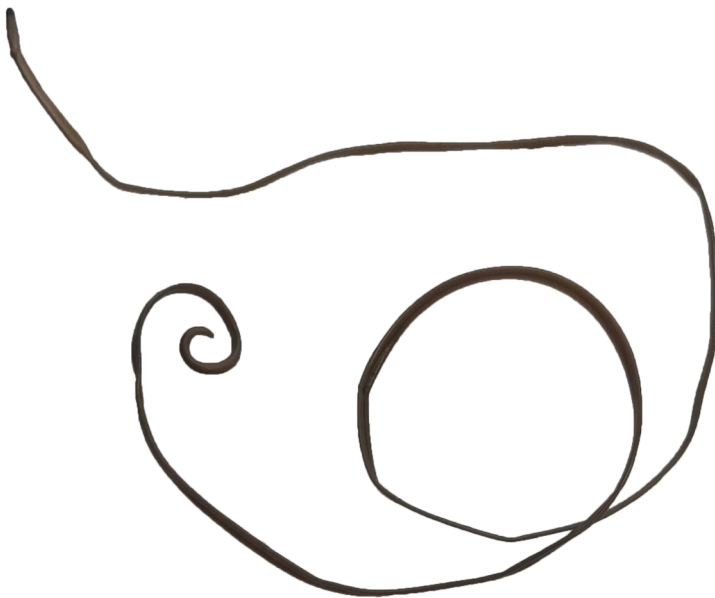
- Very long and thin
- Can grow up to 20-40"
- Unsegmented
- Featureless
- Does not break apart easily

### Some useful horsehair worm behavioral characteristics:

- Often writhes in knots
- If still, can look like a long light-colored root


### Life history details for horsehair worms:

- Larvae are parasites within aquatic and terrestrial arthropods and when mature erupt from their host's rectum upon entering water
- Some larvae chemically alter their host's brain, causing it to seek out water when it is ready to emerge
- Adults are free-living and die after reproducing



### AQUATIC EARTHWORM (ANNELIDA)

- ◉ Resembles a typical segmented earthworm
- ◉ Pale pink in color
- ◉ Found in most aquatic habitats
  - Burrows in substrate or under debris
- ◉ Feeds on any organic material
- ◉ Hermaphroditic

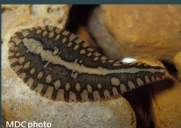


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### LEECH (ANNELIDA)

- ◉ Segmented and flattened
- ◉ Can be several inches long
- ◉ Often black or brown but some are spotted or striped
- ◉ Possess a suction disc on at least one end
- ◉ Very flexible and mobile
- ◉ Can be found in most aquatic habitats
- ◉ Some are predatory, others specialize in sucking blood from specific hosts (mammals, fish, snails, etc)
- ◉ Hermaphroditic



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## Worms: Aquatic Earthworm, Leech (Annelida)

### A checklist of important aquatic earthworm characteristics:

- Resembles a small earthworm
- Pale pink in color
- Segmented
- Breaks apart easily, fragile

### Some useful aquatic earthworm behavioral characteristics:

- Often writhes in knots
- Will readily crawl if left alone

### A checklist of important leech characteristics:

- Segmented and flattened
- Can be several inches long
- Often black or brown but some are spotted or striped
- Possess a suction disc on at least one end
- Tough skin, not fragile

### Some useful leech behavioral characteristics:

- Very flexible and mobile
- Moves by stretching forward with front and then bringing both ends together

### Life history details for aquatic earthworms and leeches:

- Both can be found in most aquatic habitats
- Both are hermaphroditic
- Aquatic earthworms burrow in substrate or under debris and feeds on any organic material
- Some leeches engulf prey, others specialize in sucking blood from specific hosts (mammals, fish, snails, etc.)

## Worms: Planarian (Platyhelminthes)

### A checklist of important planarian characteristics:

- Flat
- $\frac{1}{4}$ " – 1" long
- Arrowhead shaped head with 2 eye spots
- Mostly black or brown

### Some useful planarian behavioral characteristics:

- Will compress into flattened disc when disturbed
- Move by gliding


### Life history details for planarians:

- Can be found in most aquatic habitats
- Feed on detritus or small invertebrates
- Hermaphroditic
- Can regenerate from pieces



### PLANARIAN (PLATYHELMINTHES)


- A flat worm
- $\frac{1}{4}$ " – 1" long
- Tapered head with 2 eye spots
- Can be found in most aquatic habitats
- Feeds on detritus or small invertebrates
- Hermaphroditic
- Can regenerate from cut pieces



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### CLAM AND MUSSEL (BIVALVIA)

- Easily recognized by their 2-piece shell
- Found in rivers, streams, or ponds depending on species
  - Usually partly buried in substrate
- Filter feeders
- Their young parasitize fish to incubate
- Freshwater mussels are most diverse in the U.S.
  - 69 species found in Mo-about half are of conservation concern due to siltation, pollution, and dams



Review Insects Crustaceans Worms Molluscs Invertebrate ID

## Molluscs: Clam, Mussel (Bivalvia)

### A checklist of important clam and mussel characteristics:

- Clams and Mussels have a 2-piece shell

### Some useful clam and mussel behavioral characteristics:

- Usually partly buried in substrate

### Life history details for clams and mussels:

- Found in rivers, streams, or ponds depending on species
- Filter feeders
- Their young parasitize fish to develop
- Freshwater mussels are most diverse in the U.S.
- 69 species found in Missouri-about half are of conservation concern due to threats from siltation, pollution, and dams





## Molluscs: Snails (Gastropoda)

### A checklist of important snail characteristics:

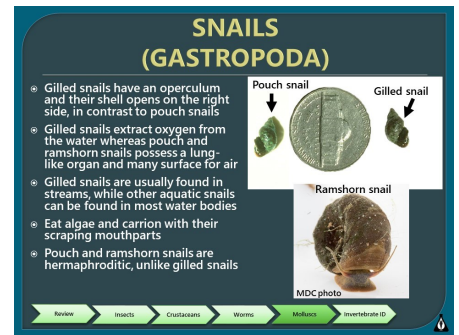
- Snails have a single shell
- Gilled snails have an operculum and their shell opens on the right side
- Pouch snails do not have an operculum and their shell opens on the left side

### Some useful snail behavioral characteristics:



- Will crawl if undisturbed

### Life history details for snails:

- Gilled snails extract oxygen from the water whereas pouch and rams horn snails possess a lung-like organ and many surface for air
- Gilled snails are usually found in streams, while other aquatic snails can be found in most water bodies
- Eat algae and carrion with their scraping mouthparts
- Pouch and rams horn snails are hermaphroditic, unlike gilled snails



# Invertebrate Identification



Size:  
3/4" - 4"

Photo by Andy Turner

Review

Insects



Crustaceans

Worms

Molluscs

Invertebrate ID

Size:  
1/2" - 1"



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Review

Insects


Crustaceans

Worms

Molluscs

Invertebrate ID

# Invertebrate Identification



Size:  
1/4" - 3/4"

Review



Insects

Crustaceans

Worms


Molluscs

Invertebrate ID




Size:  
1/4" - 1"

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MDC photo



MDC photo

Review

Insects

Crustaceans


Worms

Molluscs

Invertebrate ID




# Invertebrate Identification



MDC photo

**Size:**  
1/16" and up



MDC photo

Review


Insects

Crustaceans

Worms


Molluscs


Invertebrate ID




DNR photo

**Size:**  
1/8" - 1 1/2"







MDC photo

Review

Insects

Crustaceans



Worms

Molluscs

Invertebrate ID

# Invertebrate Identification

Adult



Size:  
1/16" – 3/8"

Review



Insects

Crustaceans

Worms

Molluscs


Invertebrate ID



MDC photo

MDC photo

Size:  
1/3" - 4"



MDC photo

Review

Insects

Crustaceans


Worms

Molluscs

Invertebrate ID

# Invertebrate Identification

Size:  
1/8" – 3/8"



Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



Size:  
Up to 1"

Review

Insects

Crustaceans



Worms

Molluscs

Invertebrate ID






# Invertebrate Identification



MDC photo

Size:  
1/4" - 1"

ReviewInsectsCrustaceansWormsMolluscsInvertebrate ID



MDC photo

Size:  
1/4" - 2"


MDC photo

MDC photo

ReviewInsectsCrustaceansWormsMolluscsInvertebrate ID



# Invertebrate Identification



MDC photo

Review


Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



Size:  
3/8"-1"

Review

Insects


Crustaceans

Worms


Molluscs

Invertebrate ID

## Invertebrate Identification




MDC photo




MDC photo

Size:  
1/16" and up

Review Insects Crustaceans Worms Molluscs Invertebrate ID






MDC photo

Size:  
Up to 40"

Review Insects Crustaceans Worms Molluscs Invertebrate ID



# Invertebrate Identification



MDC photo

Size:  
1/4" - 2"

Review


Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



Size:  
1/4" - 1"

NABS (www.benthos.org)

NABS photo

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



## Invertebrate Identification

**Size:**  
**1/4"-1"**



MDC photo

Review

Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



**Size:**  
**Less than 1/4"**



MDC photo

Review

Insects

Crustaceans


Worms

Molluscs

Invertebrate ID



# Invertebrate Identification



Size:  
Up to 1 1/2"

Photo by Tom Murray

Review


Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



Size:  
1/4" - 2"

MDC photo

Review

Insects

Crustaceans



Worms

Molluscs

Invertebrate ID



# Invertebrate Identification



Size:  
1/4"

DNR photo

DNR photo

Review

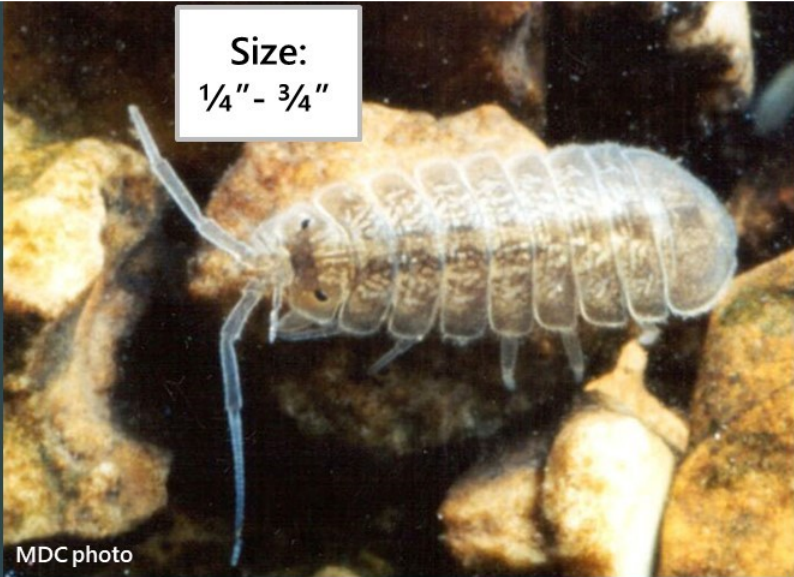
Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



Size:  
1/4" - 3/4"

MDC photo

Review

Insects

Crustaceans


Worms

Molluscs

Invertebrate ID

## Invertebrate Identification

**Size:**  
1/16" and up



Review


Insects

Crustaceans

Worms

Molluscs

Invertebrate ID



**Size:**  
1/3" - 2"



Review

Insects

Crustaceans

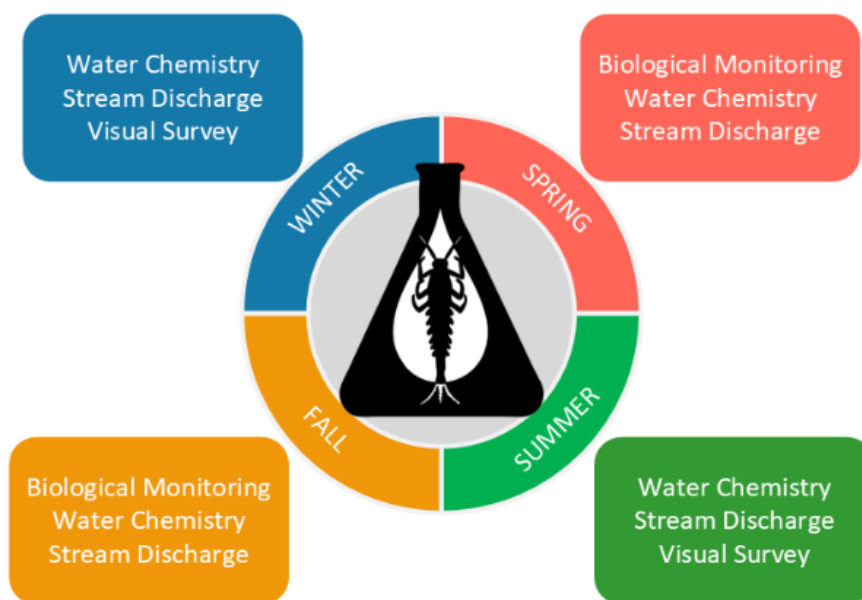
Worms

Molluscs

Invertebrate ID



# Water Quality Monitoring Procedures



## Volunteer Water Quality Monitoring Field Checklist

### General supplies

- \_\_\_\_\_ Clipboard\*
- \_\_\_\_\_ Litter bag\*
- \_\_\_\_\_ Thermometer\*
- \_\_\_\_\_ Appropriate footwear
- \_\_\_\_\_ Pencil

### Stream Discharge

- \_\_\_\_\_ Stream Discharge Data Sheet\*
- \_\_\_\_\_ Float balls\*
- \_\_\_\_\_ 100-foot measure tape\*
- \_\_\_\_\_ Stopwatch
- \_\_\_\_\_ Two sticks or stakes
- \_\_\_\_\_ 10-foot rope
- \_\_\_\_\_ Depth rod marked in tenths of a foot

### Visual Survey

- \_\_\_\_\_ Visual Survey Data Sheet\*

### Biological Monitoring

- \_\_\_\_\_ Macroinvertebrate Data Sheet\*
- \_\_\_\_\_ Hand lens or magnifier\*
- \_\_\_\_\_ Kick net\*
- \_\_\_\_\_ Forceps\*
- \_\_\_\_\_ Two 1 1/8th inch diameter rod for sides of kick net
- \_\_\_\_\_ White ice cube trays for sorting
- \_\_\_\_\_ Squirt bottle

### Chemical Monitoring

- \_\_\_\_\_ Water Chemistry Data Sheet\*
- \_\_\_\_\_ Thermometer\*
- \_\_\_\_\_ Transparency tube\*
- \_\_\_\_\_ Dissolved oxygen kit\*
- \_\_\_\_\_ Nitrate kit\*
- \_\_\_\_\_ pH meter\*
- \_\_\_\_\_ Conductivity meter\*

*\*Program provided items*

*Items can be reordered at [mostreamteam.org](http://mostreamteam.org)*



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